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ABSTRACT

This is one of several teacher's guides for the 4M Company, a set of materials for teaching metric concepts and computation. This level of the program deals with premeasurement concepts and vocabulary and introduces the basic metric units. Students compare properties of common objects directly. Students are introduced to four metric units: meter, liter, gram, and kilogram. Piagetian conservation tasks dealing with length, liquid, and mass are part of the program at this level. Included in the publication are needed materials, discussion of the activities, examples of responses for related student activities, and a minicourse on metric concepts. (RH)

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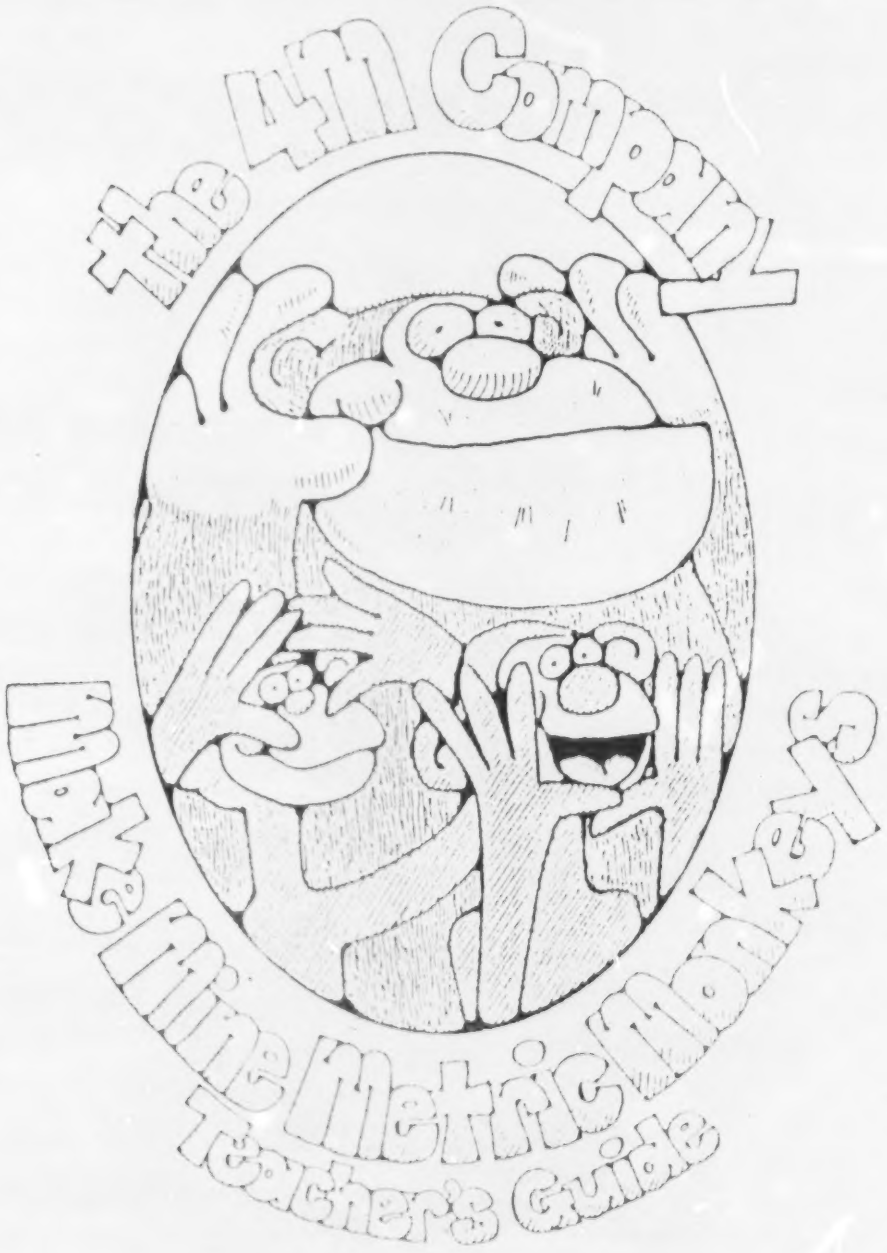

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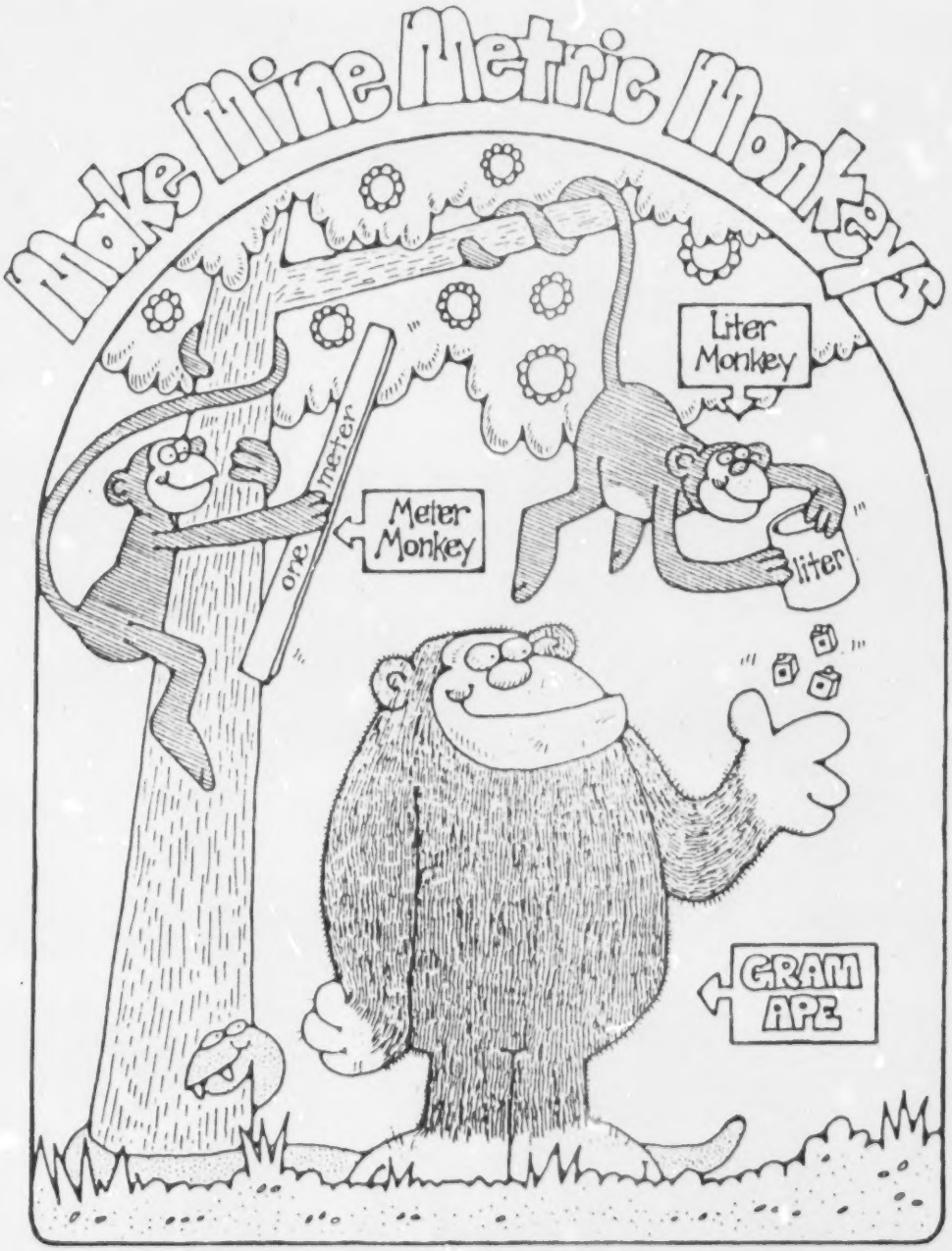
Make Mine Metric Monkeys
Liter Monkey
Meter Monkey
one meter
liter
GRAM APE

Make Mine Metric Monkeys do their monkey business in the jungle.

They measure and compare sizes of everything they find.

They always look to see units of the metric system.

They always listen to hear units of the metric system.

And they always speak about units of the metric system to all the other animals in the jungle.

Meter Monkey likes to talk about longer and shorter and the same length...and, of course, the meter.

Liter Monkey likes to talk about holding more and holding less and, of course, the liter.

The Gram Ape talks about heavier and lighter, weighs more and weighs less...and, of course, the gram and the kilogram.

Remember their motto.

See the metric system, hear the metric system, and speak the metric system.

the 4M Company

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Curriculum materials are only one of the factors involved in the learning process. No program can anticipate the other factors - your unique characteristics as a teacher, the characteristics of your students, and your classroom situation. Yet these factors must all be considered for a successful learning experience. It is you, the teacher, who must analyze these factors to make decisions and adjustments in the learning activities as described in this Teacher's Guide.

The 4M COMPANY provides a variety of classroom organizations: at times students will work as an entire class, at times they will work in small groups, and at times they will work alone. Depending on the unique combination of factors which make up your classroom, the procedures recommended in this Teacher's Guide may or may not work in your particular classroom. Feel free to adapt the program to meet your particular needs. Following the Teacher's Guide word-for-word is not important; learning the objectives of the program is!

You are a unique person, and no one will teach The 4M COMPANY exactly as you do. Your strengths, your weaknesses, your abilities, and your overall philosophy will influence your teaching. Keep in mind, however, the following roles which you must play as a teacher.

The role of a planner. The 4M COMPANY is an activity program, and you will be required to prepare materials for most lessons. Things will not always work out as you had planned, so be prepared to alter your plans if the need arises.

The role of a demonstrator. Although this Teacher's Guide outlines one approach to teaching the objectives of a lesson, you must decide if a given demonstration is working with your students. They are unique, and you may have to alter the demonstration to meet their level of understanding.

The role of a questioner. Instead of always giving answers, ask the children remedial questions that will clarify their thinking. Ask more difficult questions of children who need more challenge.

The role of a motivator. No student can be made to learn if he doesn't want to. The 4M COMPANY has tried to motivate children in several ways - the cartoon format of the booklets, the use of a story line for each grade level, and the use of games and activities. But in addition to our efforts, you will still need to motivate and encourage children to learn.

The role of a summarizer. At the conclusion of an activity, you encourage students to share their findings. It is important to summarize the results of each activity.

We have tried to make The 4M COMPANY an enjoyable and effective metric program. To a large extent your attitude will determine the success of the program. If you are unfamiliar with parts of the metric system, admit this to yourself and to your students. If you adopt a positive attitude of learning with your students, this will do much to create a good classroom environment. For ready reference, the Appendix to this Teacher's Guide contains a brief review of the metric system.

The following paragraphs deal specifically with this level of The 4M COMPANY. Please read them carefully.

content

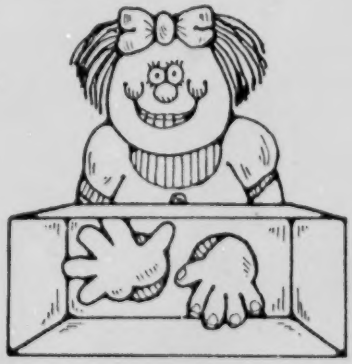
This level of the program deals with premeasurement concepts and vocabulary and introduces the basic metric units. Students compare properties of common objects directly. Vocabulary is limited to comparatives (longer, heavier, etc.). Students are introduced to four metric units: meter, liter, gram, and kilogram. They compare these units to properties of common objects. Piagetian conservation tasks dealing with length, liquid, and mass are a part of the program at this level. When a child conserves he understands that the length (or amount of liquid, or mass) of an object does not change if it is repositioned in space. Mastery of conservation is not expected of all students at this age level, but exposure to the concepts is important.

management

Management will be a key factor in the success of this program. In general, kindergarten and first grade children will need direct supervision on most activities. There are two workbook pages for each new concept. The first page should be done as a group with plenty of discussion. Children can then do the second page on their own. Be sure to discuss the pages after they are completed. Do not let children work ahead on their own since directions change from page to page.

feel box

The Feel Box has been found to be very successful and is easily made from a cardboard box. Two holes are cut in the bottom of an open rectangular box. The box will be turned on its side and children asked to stick their hands through the holes to hold and compare objects by feel rather than by sight. Care should be taken not to make the holes so large that children can easily see into its open side. Sleeves or cuffs may be placed around the holes, as well, to prevent peeking.



coloring

Many students enjoy coloring the pictures in their metric booklets. This can serve as an aid in classroom management. While you work with a small group, others can color in their books. However, no child should be forced to color, and care should be taken not to compare or judge the quality of the coloring.

spelling

At the time of printing there was no national policy on the spelling of the words "meter" and "liter". Some groups are advocating "metre" and "litre". We have gone with the "er" spellings. However, since students will probably see both spellings, it is a good idea to expose them to both. Both spellings are correct.

suggestion

Here is another suggestion which you may find helpful. When several illustrations appear on one page, some kindergarten and first grade children have difficulty focusing their attention on a given exercise. To help students focus their attention, give each child a piece of construction paper (10 cm x 15 cm) so that they can use it to block out pictures not being discussed.

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materials

section number	materials description
1	a variety of objects to compare, Feel Box, Cuisenaire rods or attribute blocks or large and small squares cut out of construction paper
2	Feel Box, meter stick, paper and tape
3	a variety of objects which differ in length, scissors, string, masking tape, meter stick, Feel Box, adding machine tape, Cuisenaire rods (if available)
4	pencils (2 the same length, others different) or straws, string, scissors
5	pencils of same length, wooden dowels, straws, pipe cleaners, string
6	pairs of similar objects to be compared relative to size, attribute blocks if available; wooden dowels or 2 long thin pencils, 1 long fat pencil, and one short fat pencil; Feel Box
7	balance, assorted things to compare by weight, kilogram weight, gram weight, Feel Box
8	balance, modeling clay or Play Doh
9	a variety of containers, liter measure, container larger than a liter (bucket), water, empty quart and half gallon milk cartons
10	two identical transparent containers (baby food jars are good), 1 tall thin container (stuffed olive jar is good), water (colored water works well)

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section 1 larger/smaller, bigger/littler

Objectives: Given two physical objects, identify the larger/smaller, bigger/littler.

Given an illustration of two objects, identify the larger/smaller, bigger/littler.

Given the names of two common objects which differ greatly in size, identify the larger/smaller, bigger/littler.

Materials: a variety of objects to compare, Feel Box, Cuisenaire rods or attribute blocks or large and small squares cut out of construction paper

Vocabulary: larger, smaller, bigger, littler

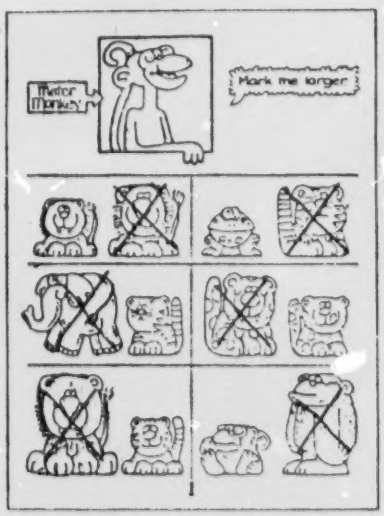
SUGGESTED PROCEDURE AND ACTIVITIES:

1. Begin by holding up two objects which differ in size and ask, "Which is larger?" Point out the larger one and after several examples, ask a child to identify the larger of two objects. Repeat with other children. Cuisenaire rods could be used here.

2. Select some object in the classroom (book, pencil, desk) and ask a child to find an object larger than the given object. Repeat several times.

3. Then do pages 1 and 2 in the student booklet. Work an example or two on the chalkboard before assigning the pages. Draw a large and small circle on the board, ask for a volunteer to come forward and mark the larger. Etc.

4. Repeat activities 1, 2 and 3 using the concept "smaller": identify the smaller of two objects, find an object smaller than a given object, then do pages 3 and 4 in the workbook.



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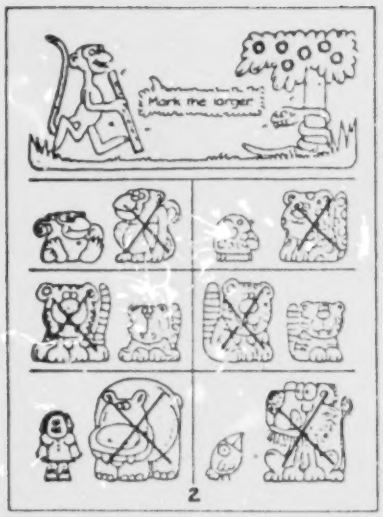
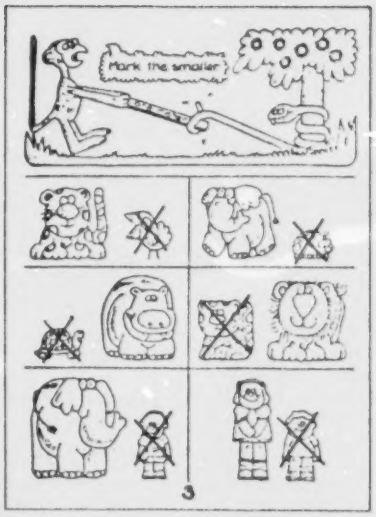
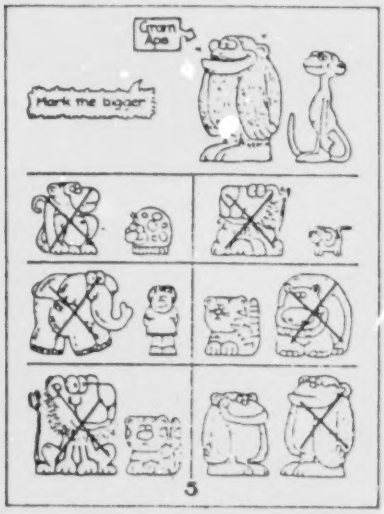
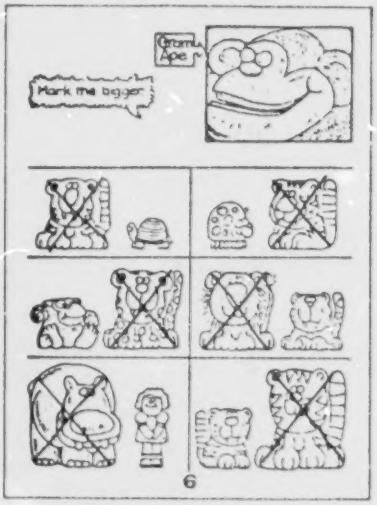
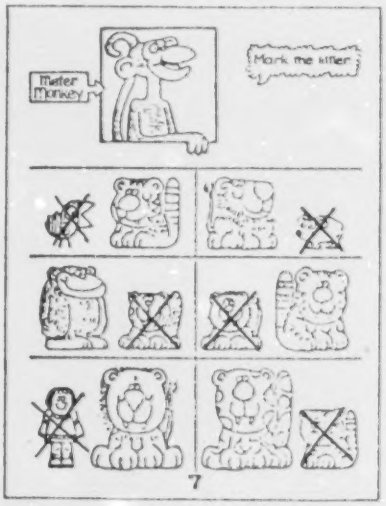




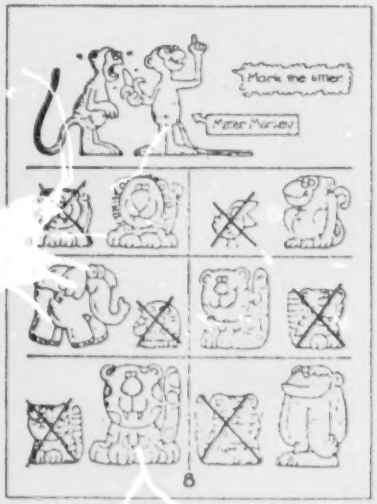






5. Repeat activities 1, 2 and 3 with "bigger". Assign pages 5 and 6.

6. Repeat activities 1, 2 and 3 with "littler". Assign pages 7 and 8.



7. When the workbook pages are completed, introduce the Feel Box. Have one child demonstrate how to place both hands into the box to feel objects. Then let each child have a turn. Place two objects into the box and ask the child, "Which is larger? Which is smaller?"

8. Ask the children to name the largest object they know, then the smallest; largest animal in the zoo, then a smaller one, a bigger one, a littler one; etc.

9. Call out the names of two common objects which differ greatly in size, e.g., mouse and elephant. Have students identify the larger. Repeat with other words, asking for the smaller, bigger, or littler.

10. From the set of Cuisenaire rods (or paper squares or attribute blocks) take out three large objects (same size) and three small objects (same size). Demonstrate to the children how to put all the large ones together and all the small ones together. Sometime during the day you should individually check each student on this task.

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section 2 taller/shorter

Objectives: Given two physical objects, identify the taller/shorter.

Given an illustration of two objects, identify the taller/shorter.

Given the names of two common objects which differ greatly in height, identify the taller/shorter.

Materials: Feel Box, meter stick, paper and tape

Vocabulary: taller, shorter, meter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Demonstrate the concept of "taller" by comparing the heights of two children.

2. Draw a tall object and a short object on the chalkboard. Mark the taller one. Repeat, letting children mark the drawing. Then as a group work through pages 9 and 10 in the workbook, marking the object that is taller in each picture.

3. Repeat activities 1 and 2 with the concept "shorter", assigning pages 11 and 12.

4. Have children stand in a circle. Call on one child to name someone taller than he is. Have them stand back-to-back so that everyone can see who is taller. Let the taller child select someone shorter, etc.

5. Introduce the meter stick. "The meter is used to tell how long or how tall something is." Tape a long sheet of paper against a door or wall (about 1 1/2 meters tall and 20 cm wide). Tape a meter stick touching the floor and along one edge of the paper. Have children stand against the paper and mark the height of each child, printing each child's name by his mark. Ask each child if he is taller or shorter than a meter.

6. Game: Divide the class into two groups. The teacher is the game monitor and is responsible for calling out the name of two objects to be compared using taller/shorter.
Examples: mouse vs. elephant, grass vs. tree, fly vs. tiger, button vs. ball, lizard vs. dog, ant vs. cat, chair vs. house, book vs. desk, flower vs. fence, bicycle vs. car, pencil vs. telephone pole, meter stick vs. door, etc.
She alternates from one group to the other, asking individual children for the correct response. If a child is incorrect, he must sit down. The group with the most children standing when "time" is called wins.

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section 3 longer/shorter

Objectives: Given two physical objects, identify the longer/shorter.

Given an illustration of two objects, identify the longer/shorter.

Given the names of two common objects which differ greatly in length, identify the longer/shorter.

Given a meter stick, find objects longer/shorter than one meter.

Materials: a variety of objects which differ in length, scissors, string, masking tape, meter stick, Feel Box, adding machine tape, Cuisenaire rods (if available)

Vocabulary: longer, shorter, meter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Introduce the concept of longer by holding up two pencils which vary in length. Place the pencils side by side so that the eraser ends are even. Then compare the other ends. "This pencil is longer because it sticks out more when the other ends are even." Demonstrate with many other objects, asking the class to tell which is longer.

2. Place many objects on the table. Hold one up, and ask someone to come forward and find an object on the table which is longer. Repeat so that many children can participate.

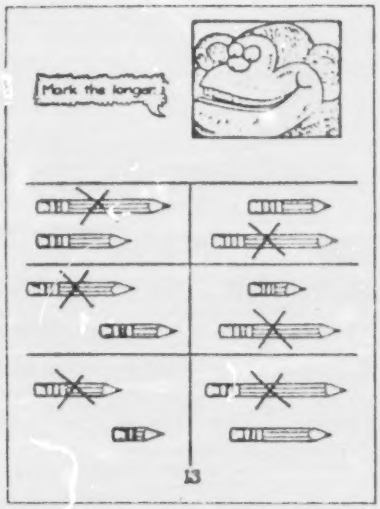
3. Select an object in the classroom and ask if someone can find a longer object. Repeat several times.

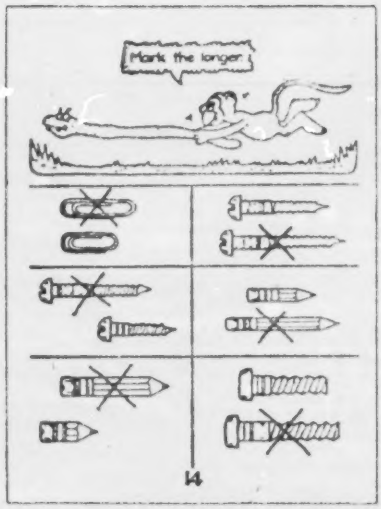
4. Use the Feel Box to see if children can identify the longer of two objects by feel. Cuisenaire rods are ideal here.

5. Tape a strip of masking tape on one end of the chalkboard. Tape another strip on the other end of the board. Ask which is longer. Tell them that they cannot move the strips next to each other. Ask the students to find a way to tell which strip is longer. A solution might be: a.) Cut a piece of string the same length as one strip of tape. Compare the length of the string with the length of the other strip. b.) match the length of a certain object with one strip of tape; match the length of another object with the other strip of tape; then match the two objects and compare the lengths.

6. Work pages 13 and 14 as a group. Do an example on the chalkboard if necessary.

7. Repeat activities 1-6 using the concept "shorter"; assign pages 15 and 16.





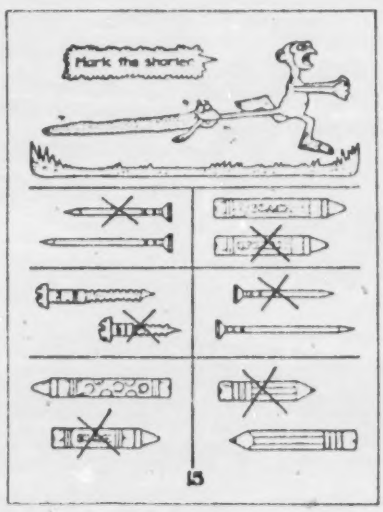
8. If enough Cuisenaire rods are available, give each child a blue and yellow rod. Have them hold the rods behind their backs, shift from hand to hand, then, on signal, ask them to hold up the longer. See if everyone holds up the blue rod. Then use brown and orange (these differ by 2 units). Finally, use the light green and red rods (these differ by 1 unit).

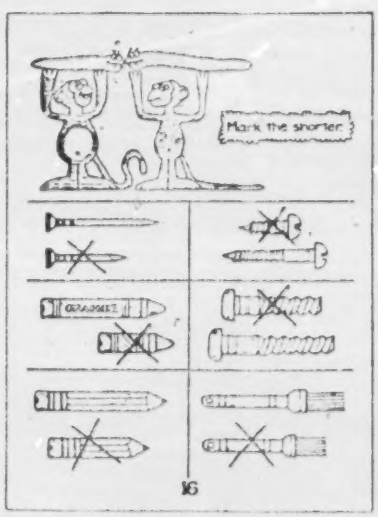
9. Introduce the meter stick and as a group find things in the room longer or shorter than a meter.

10. Let children cut strips of adding machine tape the same length as a meter. Supervise, and write each child's name on his meter. Let each child find one thing longer and one thing shorter than a meter. Share findings in a group discussion.

11. As a group activity, measure the length of the room in meters. First guess, then let children, one child at a time, lay their meters end to end until the length of the room is covered. Count the number of meters. "The room is about _____ meters long." Be sure to point out that the meters should fit snugly end to end with no overlapping or gaps between them.

12. Call out the names of two common objects which differ greatly in length, for instance a crayon and a meter stick. Have students identify the longer (or shorter).





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the 4M Company

section 4 same length

Objectives: Given two physical objects, determine by direct comparison if they have the same length.

Given an illustration of pairs of objects, identify those which have the same length.

Materials: pencils (2 the same length, others different) or straws, string, scissors

Vocabulary: same length

NOTE: In this section students learn how to compare lengths by direct comparison. They line up one set of ends and compare the other ends to determine the longer or shorter. This is an important skill.

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up two pencils which are the same length and ask, "Which pencil is longer?" Then place them side by side to compare their lengths. Point out that both ends are even. "This means the pencils have the same length."

2. Take two pencils the same length and hold them in your hands so that the eraser ends are covered (in your hands) and the other ends are at different heights. Ask, "Do these pencils have the same length?" After they guess, discuss how to verify their guesses by pointing out that we have to look at both ends. Place the pencils so that the eraser ends are even. "See, these pencils have the same length because both ends are even." Repeat with pencils of different lengths.

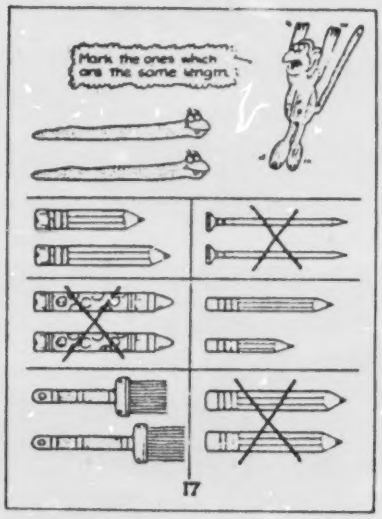
3. Now hold two pencils in your hands so that the visible ends are even. Ask, "Are these pencils the same length?" As before, both ends must be compared. Repeat with a variety of different lengths.

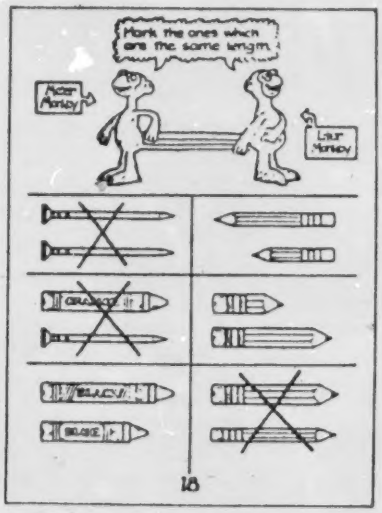
4. Tape a piece of masking tape (about 12 cm long) near the top of the chalkboard. Then pose a question: "Is your foot the same length as this piece of tape?" Since students cannot place their feet on the board to compare directly, ask the class how they might find out if their feet are the same length as the piece of tape. If no one suggests it during the discussion, you should suggest that children cut string the same length as their feet. Line the children up, and, one at a time, cut a piece of string as long as their feet. Then let each child come forward with his string, stand on a chair, and compare his "foot" to the piece of tape.

5. Challenge each child to use the string from activity 4 to find something in the room which has the same length as his foot.

6. Set out several pairs of pencils, some with the same lengths, others whose lengths vary. Check each child to make sure he knows how to compare the lengths of two objects by direct comparison (by lining up one set of ends and comparing the other).

7. Work pages 17 and 18 as a group.





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section 5 conservation of length

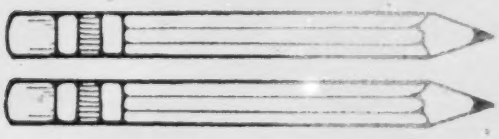
Objectives: Given two objects with equal lengths, state that both are still the same length when one of them is moved. (Mastery not expected of all children at this age level.)

Materials: pencils of same length, wooden dowels, straws, pipe cleaners, string

Vocabulary: longer, shorter, same length

SUGGESTED PROCEDURE AND ACTIVITIES:

1. It is preferable to work in small groups. Take two pencils (or other objects) of equal length. Place them on a table as follows:



Ask, "Which is longer, or are they the same length?" After it is established that they are the same length (you may have to hold them side by side), move one pencil so that they look like this:

Ask, "Which is longer, or are they the same length?" If children cannot conserve length, their perceptions will fool them and they will say that one of the pencils is longer. If so, explain that moving a pencil does not change its length.

2. Repeat with straws, dowels, etc. Ask different children to respond.

3. Take two pipe cleaners of equal length. Place them side by side and ask, "Which is longer: or are they the same length?" After it is determined that they are the same, bend one and repeat the questions. Explain that bending a pipe cleaner does not change its length although it does change its shape. A little bug walking from one end to the other would still walk the same distance.

4. Repeat with 2 equal lengths of string. Make one wiggly like a snake.

the 4MM Company

section 6 same size

Objectives: Given an illustration of three objects, identify those which are the same size.

Given pairs of pencils which may vary in length and thickness, identify those which are the same size.

Materials: pairs of similar objects to be compared relative to size, attribute blocks if available; wooden dowels or 2 long thin pencils, 1 long fat pencil, and one short fat pencil; Feel Box

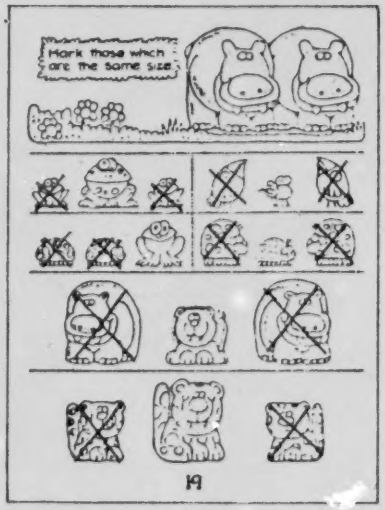
Vocabulary: same size, different size, fat, skinny, thick, thin

SUGGESTED PROCEDURES AND ACTIVITIES:

1. Using the Feel Box, have students feel two objects at a time, and ask if they are the same size. If they are not ask which is larger (or smaller) etc.

2. If available, use a flannel board to compare sizes.

3. Workbook, pages 19 and 20. Before assigning pages, draw three circles on the chalkboard, two of which are the same size. Demonstrate how to mark the two which are the same size. Repeat, letting different children come forward to mark the two which are the same size. Then assign pages.

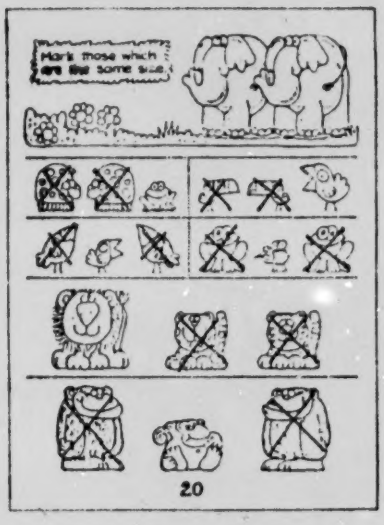


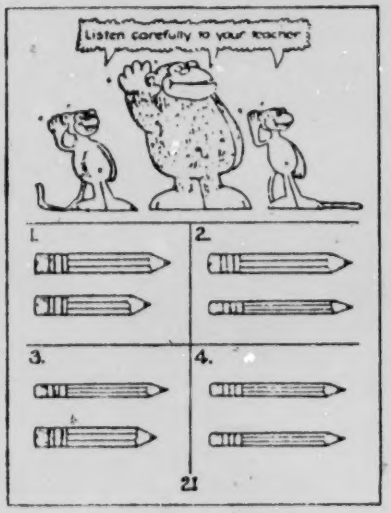
4. Use dowel rods or pencils. Choose 2 dowels which are identical. Ask, "Are these the same size?" Then choose one which is the same length, but of a different diameter. Repeat the question. Bring out that they have the same length, but different thicknesses. "One is fatter" or "one is skinnier" is acceptable language. Then compare

a short, fat rod with a long, skinny rod. Repeat the question. Bring out that each is "big" in one way: one because it is fatter, the other because it is longer.

5. Feel Box. See if children can distinguish "fat" from "thin", etc.

6. Have students turn to page 21. For each problem ask, "Are these pencils the same size?" In problem 1, they are both fat, but one is longer than the other. So they are not the same size. In problem 2, they are the same length, but one is fat and one is thin. In problem 3, one is longer, but the other is fatter. In problem 4, they are the same size because they have the same length and thickness.





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section 7 heavier/lighter

Objectives: Given two physical objects and a balance, identify the heavier/lighter by feel and verify results using the balance.

Given an illustration of two objects on a balance, identify the heavier/lighter.

Given a 1-gram weight and balance, find objects heavier/lighter than one gram.

Given a 1-kilogram weight and balance, find objects heavier/lighter than one kilogram.

Given the names of two common objects which differ greatly in mass, identify the heavier/lighter.

Materials: balance, assorted things to compare by weight, kilogram weight, gram weight, Feel Box

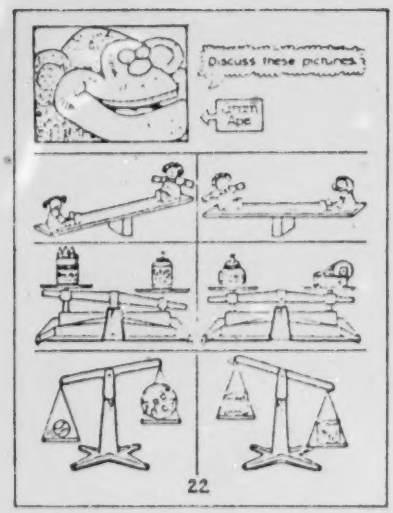
Vocabulary: balance, heavier, lighter, kilogram, gram, weighs more, weighs less

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up two objects which vary in weight and place them on a balance. Explain that one is heavier because it makes the balance "go down" on its side. Place some objects on a table and have students, one at a time, guess by feel, then use a balance to determine the heavier of two objects.

2. Select an object and ask if someone can find a heavier object. Let several children participate.

3. Using a balance to demonstrate, discuss the six examples on page 22. Note that: 1) sometimes small things are heavier than big things; 2) that sometimes neither object is heavier (we say they have the same weight or mass) and the balance balances or stays even; and 3) that even if things are the same size one may be heavier than the other. Make some specific comparisons to



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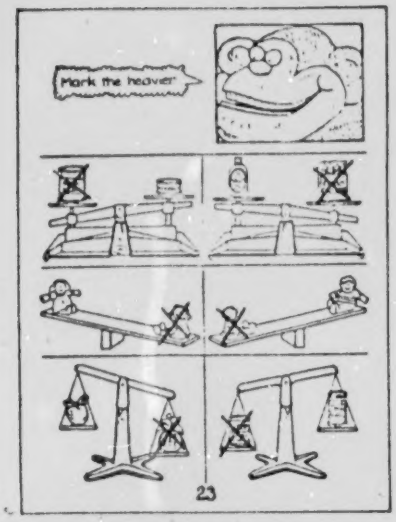
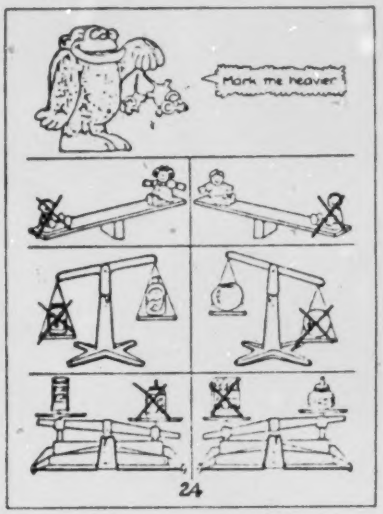
point these out. For example: large styrofoam ball and small steel ball, small steel cube and small aluminum cube, glass marble and same sized steel ball, two gram weights.

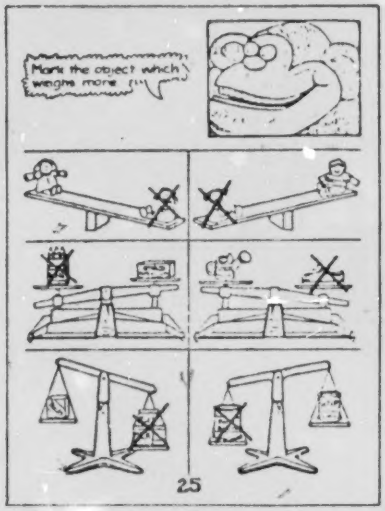
4. Do pages 23 and 24 as a group.

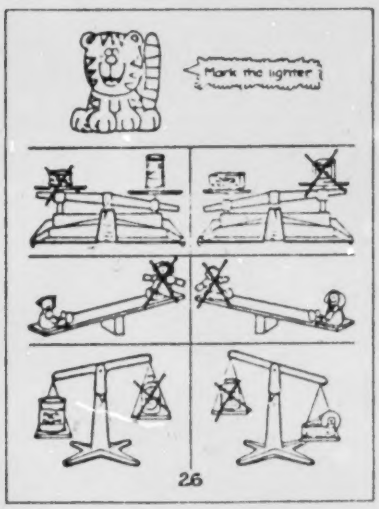
5. Explain that if one object "weighs more" than another object, it means that object is heavier and will make the balance go down. Hold up 2 objects; tell the class "This one weighs more, so which way will the balance go?" Put them on the balance to check. Do more examples with the balance and "weighs more". Do page 25 as a group.

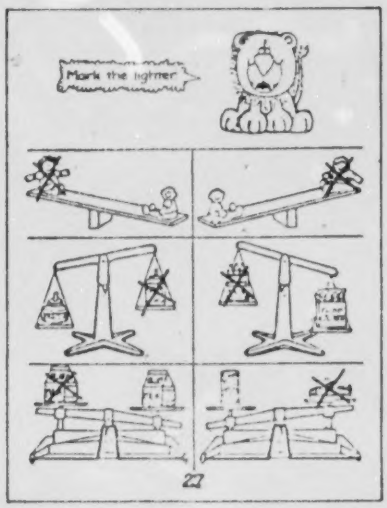
6. Repeat activities 1 and 2 using the concept "lighter". Assign pages 26 and 27.











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7. Explain that if one object "weighs less" than another object, it means that object is lighter and when both objects are put on the balance it will be on the side that goes up. Hold up 2 objects; tell the class "This one weighs less, so which way will the balance go?" Check on the balance. Put 2 more objects on the balance. Point to one at a time and have the children tell you that it "weighs more" or "weighs less". Do page 28 as a group.

8. Let the children find objects in the room to compare. In front of the group let each child act like a scale holding one object in each hand. The hand with the heavier object goes down, the hand with the lighter object goes up. Let children check their objects on a balance. Leave materials and balance out so that children can play with them during free time.

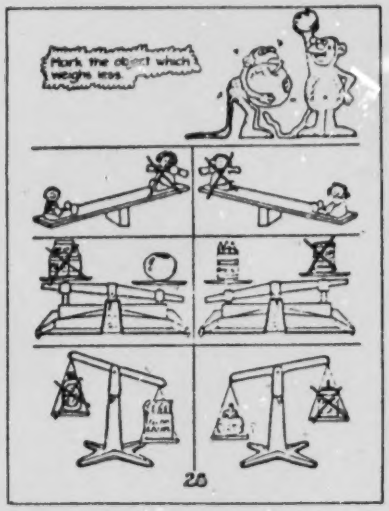
9. If available use a teeter board to compare various children in the class. Compare the middle sized children and avoid any possible embarrassment to children who might be sensitive about their weights.

10. Introduce a kilogram weight as a unit of weight (mass) in the metric system. Let the class try to find objects heavier and lighter than a kilogram. Check on balance.

11. Now introduce the gram. Explain that kilograms are used for weighing heavy things and that grams are used for weighing lighter things. Let each child feel a gram weight. Then ask each child to try to find something lighter and heavier than a gram. As a group check each child's items on a balance. You might want to provide a box of light objects, such as bottle caps, feathers, sticks, pins, ecc.

12. Call out the names of two objects which differ markedly in weight. e.g., a truck and a car, a kilogram-weight and a pencil. Have students identify the heavier/lighter.

13. Throughout this section the children should be gaining the idea that: **heavier** means "weighs more", and **lighter** means "weighs less", heavier means the balance goes down, and lighter means the balance goes up.



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section 8 conservation of mass (weight)

Objectives: Given two equal masses, state that the masses remain equal when changed into different shapes. (Mastery not expected of all children at this age level.)

Materials: balance, modeling clay or Play Doh

Vocabulary: weighs more, weighs less, heavier, lighter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Balance two lumps of clay on a balance. (Pinch off one, add to the other until they balance.) Then roll one into the shape of a long sausage. Ask: "If I put both lumps of clay back on the balance, will one be heavier?" They will weigh the same, of course. Let children try to explain why they still balance. Then explain that the shape of an object does not determine its weight.

2. Then divide one lump into four or five lumps. Ask whether or not one side will be heavier. Check it on the balance. Discuss.

3. Repeat with various shapes. Give every child a chance to respond if possible.

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section 9 holds more/holds less

Objectives: Given two containers, identify the one which holds more/holds less.

Given an illustration of two containers, identify the one which holds more/holds less.

Given the names of two common objects which differ greatly in capacity, identify the one which holds more/holds less.

Given a liter measure, find containers which hold more/hold less than one liter.

Materials: a variety of containers, liter measure, container larger than a liter (bucket), water, empty quart and half gallon milk cartons

Vocabulary: holds more, holds less, liter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Select two clear containers, one obviously larger than the other. Ask which container holds more. Then fill the smaller with water and pour into the larger. Since there is still empty space in the larger, this means it holds more water than the smaller container. Empty both, and fill the larger container. "What will happen if I try to pour all this water into this container?" (Point to the smaller container.) Hopefully the children will say, "It will spill" or "It won't all fit". Then pour from the larger to the smaller container, showing that there is some water left over. Explain that this means the larger container "holds more" than the other one.

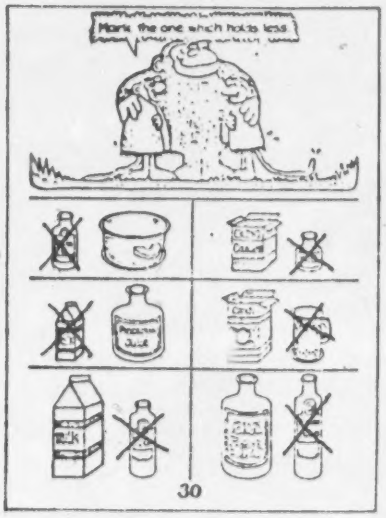
2. Have a child come forward. Set out 2 containers and ask which holds more and which holds less. Have the child guess then verify the guess by filling one container with water, then pouring it into the other. Let all children have a turn. This activity need not be done in one day.

3. Introduce the liter. Explain that it is used to measure liquid in the metric system. Ask the class to find containers which hold more or less than a liter. Pour water to see if their guesses were correct.

4. Help students complete pages 29, 30.

5. Discuss what kinds of things might be sold in liter sizes. Bring in empty quart and half gallon milk cartons. See if they hold more or less than a liter.

6. Call out the names of two things that hold liquid. Have students identify the one which holds more/holds less. Examples: swimming pool, bathtub, coffee cup, teaspoon, pitcher, soda can, milk carton, aquarium, bucket, gasoline tank truck, liter, drinking glass, sink.



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section 10 conservation of liquid

Objectives: Given two equal amounts of liquid, state that the amounts remain equal when one of them is poured into a different-shaped container. (Mastery not expected of all children at this age level.)

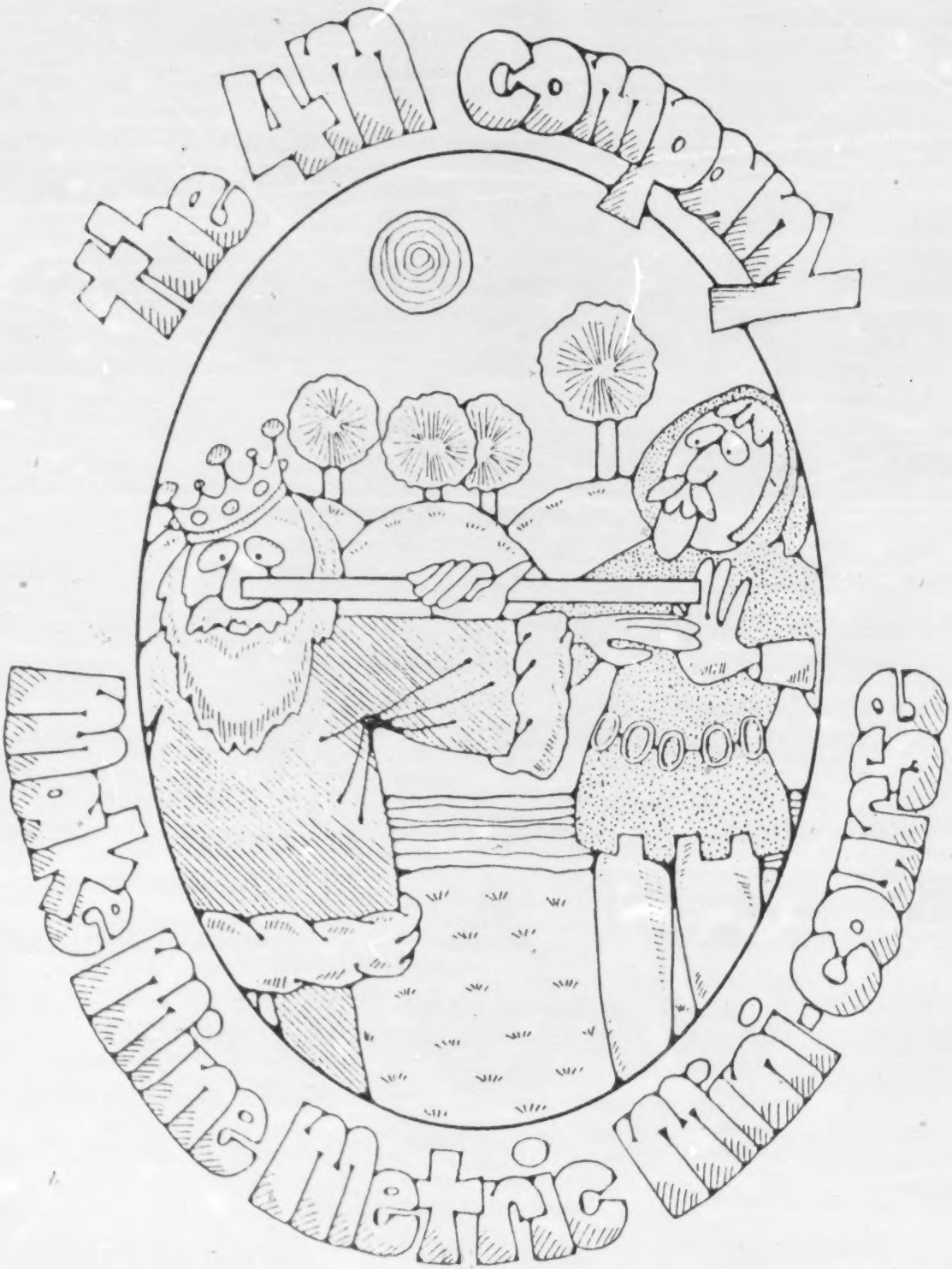
Materials: two identical transparent containers (baby food jars are good), 1 tall thin container (stuffed olive jar is good), water (colored water works well)

Vocabulary: more, less, same

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Fill two containers with water so that they hold the same amount. Get the class to acknowledge that there is the same in each container, then pour the contents of one into the third container. Ask, "Now do we have the same amount of water or does one container have more water?" Discuss, then pour the water back.

2. If you have other containers, repeat the procedure several times. Permit children to pour water themselves.



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INTRODUCTION

This mini-course is designed to serve two purposes: 1) a quick review of metrics for teachers who have attended a metric workshop; and 2) a basic introduction to the metric system for teachers who have not attended a metric workshop. If studied seriously, we feel the contents of this mini-course can prepare a teacher to teach the metric system. However, don't expect to be an expert right away. Even teachers who have attended a workshop frequently forget much of what they learned. As most teachers know, we usually don't know a subject well until we have taught it a time or two. The same will be true of metrics.

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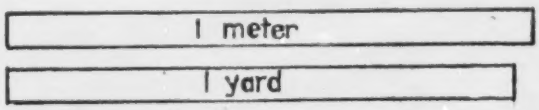
LESSON 1: THE METER, THE LITER, AND THE GRAM

The three most common metric units are the meter (for measuring length or distance), the liter (for measuring liquid or granular capacity), and the gram (for measuring weight). Select a meter, a liter, and a gram from your metric supplies.

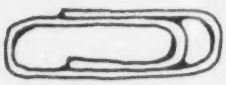
The meter is the main unit of length in the metric system. Stand up and hold the meter stick on the floor against your leg. How high up your leg does it come? To your hip? To your waist? Remember the spot and you'll always have some idea of a meter. A meter is just a little longer than a yard -- 39.36 inches.



The liter is the main unit of capacity in the metric system. It was originally defined to be the capacity of a cube each of whose sides was 1/10th of a meter long.

Take a good look at the liter. Does it appear to be about the size of any English unit? Actually, the liter is slightly larger than a quart (6% larger, to be exact).

Now pick up the gram, the main unit of weight in the metric system. Pretty light, isn't it? If you look at the protein, fat, and carbohydrate content of the sides of cereal boxes you'll notice that the weights are given in grams. A paper clip weighs about one gram. A nickel weighs 5 grams.



weighs 1 gram

weighs 5 grams

These three units - meter, liter, and gram - are the heart of the metric system necessary for everyday measuring. Try to remember the size of each unit: the meter is a little longer than one yard; a liter is a little larger than a quart; and a gram is the weight of a paper clip.

LESSON 2: OTHER UNITS - PRESTO!

In the English system of measurement there are 14 units of length, and there is no systematic relationship between them:

12 inches = 1 foot

3 feet = 1 yard

5½ yards = 1 rod

40 rods = 1 furlong

8 furlongs = 1 mile

etc.

One would have to be a near-genius to remember all the relationships in the English system!

By comparison, the metric system is simple (although it may not seem so at first). In the metric system there is one base unit for each physical property to be measured. To form units larger or smaller than the base units, a system of prefixes, each of which is a power of ten, is used. For units smaller than the base units, the Latin words for tenth, hundredth, and thousandth are used (deci, centi, and milli). To form units larger than the base units, the Greek words for ten, hundred, and thousand are used (deka, hecto, and kilo). The new units are formed by placing the prefixes in front of the base units.

	LENGTH	CAPACITY	MASS (WEIGHT)
1000	kilometer (km)	kiloliter (kℓ)	kilogram (kg)
100	hectometer (hm)	hectoliter (hℓ)	hectogram (hg)
10	dekameter (dam)	dekaliter (daℓ)	dekagram (dag)
1	meter (m)	liter (ℓ)	gram (g)
0.1	decimeter (dm)	deciliter (dℓ)	decigram (dg)
0.01	centimeter (cm)	centiliter (cℓ)	centigram (cg)
0.001	millimeter (mm)	milliliter (mℓ)	milligram (mg)

Whenever kilo is heard, we know immediately that we have 1000 of the base unit, whatever it is. Thus, kilometer is 1000 meters, kiloliter is 1000 liters, kilowatt is 1000 watts, etc. (The watt is a unit of power.) Or, millimeter is 0.001 meter, milliliter is 0.001 liter, etc.

The writing of metric units is simplified by the use of symbols: m stands for milli, c for centi, d for deci, da for deka (the a is needed to distinguish deci from deka, both of which start with d), h for hecto, and k for kilo. Also, m for meter, ℓ for liter, and g for gram. Thus kg is kilogram, mℓ is milliliter, etc. In the next lesson you will practice using these metric prefixes.

LESSON 3: PRACTICE WITH PREFIXES

In this lesson you will practice using metric prefixes. Use the table in Lesson 2 to help you complete the following equations. Answers appear at the end of the Teacher's Guide.

100 grams =	hectogram	100 liters =	
10 liters =		1000 liters =	
1000 meters =		1000 grams =	
0.001 gram =		10 meters =	
100 liters =		0.1 meter =	
0.01 gram =		0.1 liter =	
0.001 meter =		0.01 liter =	
0.01 meter =		0.1 gram =	
0.001 liter =		10 grams =	

Keep going! Try these!

10 cards = dekacards (get it?)

0.1 Arnaz = _____

0.01 mentalist = _____

1000 manjaros = _____

0.001 tary = _____

0.1 mate = _____

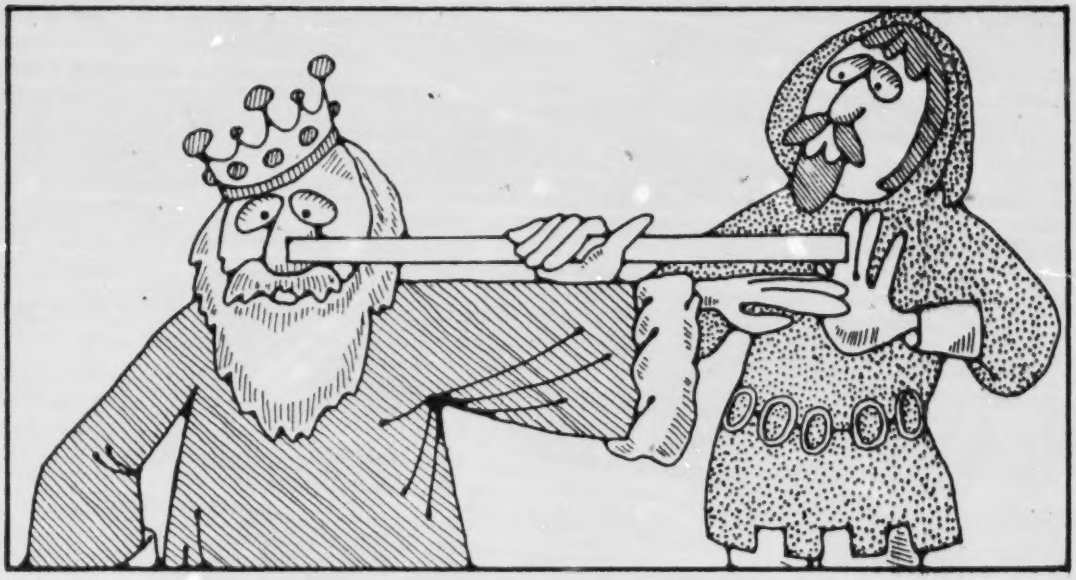
1000 whats? = _____

0.001 scent = _____

0.01 pede = _____

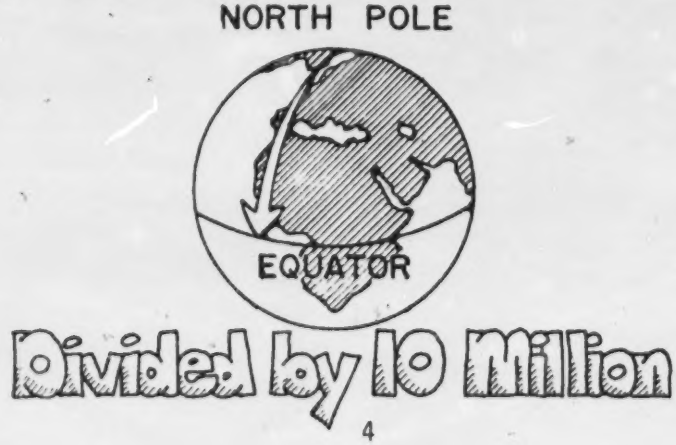
LESSON 4: A BRIEF HISTORY OF THE METRIC SYSTEM

Prior to 1790, the measurement systems of Europe were based on arbitrary objects: an inch was once defined to be the length of 3 kernels of barley corn placed end-to-end; a rod was the combined left feet of the first 16 men coming out of a specific church on Sunday morning; an acre was the amount of land a team of oxen could plow in one day; the yard was the distance from the tip of King Henry I's nose to the tip of his extended middle finger; etc.



A similar hodge-podge of units was used in France at the time of the French Revolution. In 1789, the French Academy of Sciences was requested by the National Assembly to devise a new measurement system. The French Revolution was underway, and because of the antiaristocratic attitude of the French people, a change to a system not based on dimensions of royal monarchs was highly acceptable to them.

In developing the metric system the French scientists had three major objectives. The first objective was to find a unit of length that was measurable and reproducible everywhere, and natural in the physical world. To meet this objective, the meter was defined to be one ten-millionth of the distance from the equator to the north pole.



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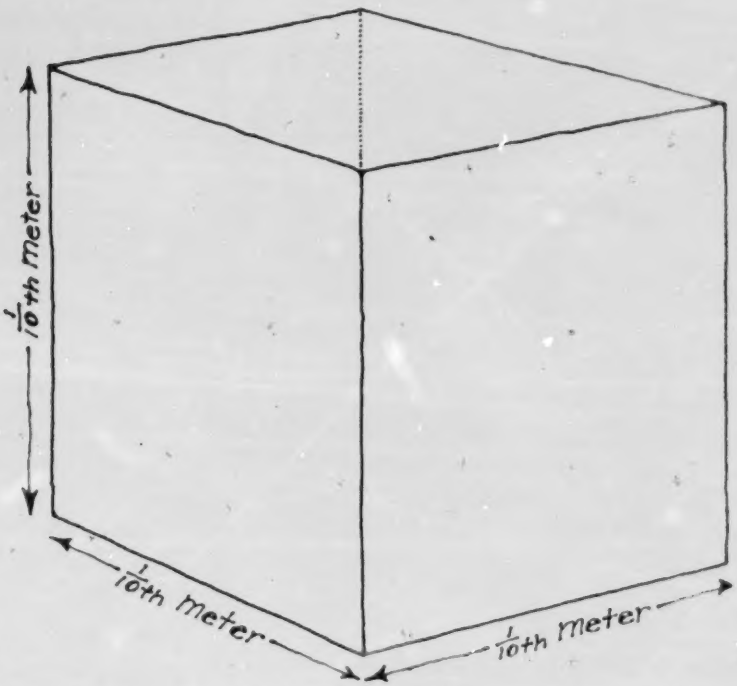
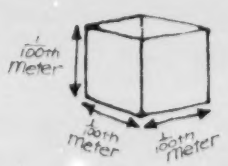
The second objective was to relate the unit of length to other units of measurement. For the main unit of capacity they selected a cube, with each of its sides equal to 1/10th of a meter (cubic decimeter), and called the amount of space contained within this box-shaped figure a "liter."



Liter

For the main unit of mass, the French scientists took a cube with each of its sides equal to 1/100th of a meter (a cubic centimeter), filled this box with pure water at 4° Centigrade, and designated the mass of this water as a "gram." Thus, the meter was used to define both the liter and gram.



Gram

The third objective was to simplify the conversion from one unit to another. We have already seen how a system of prefixes, which are powers of ten, was used to accomplish this objective. Since each metric unit is ten times larger than the next smaller unit, converting from one unit to another can be accomplished by merely moving a decimal point. Thus

35 meters =
- 0.035 kilometers
- 0.35 hectometers
- 3.5 dekameters
- 350 decimeters
- 3500 centimeters
- 35 000 millimeters

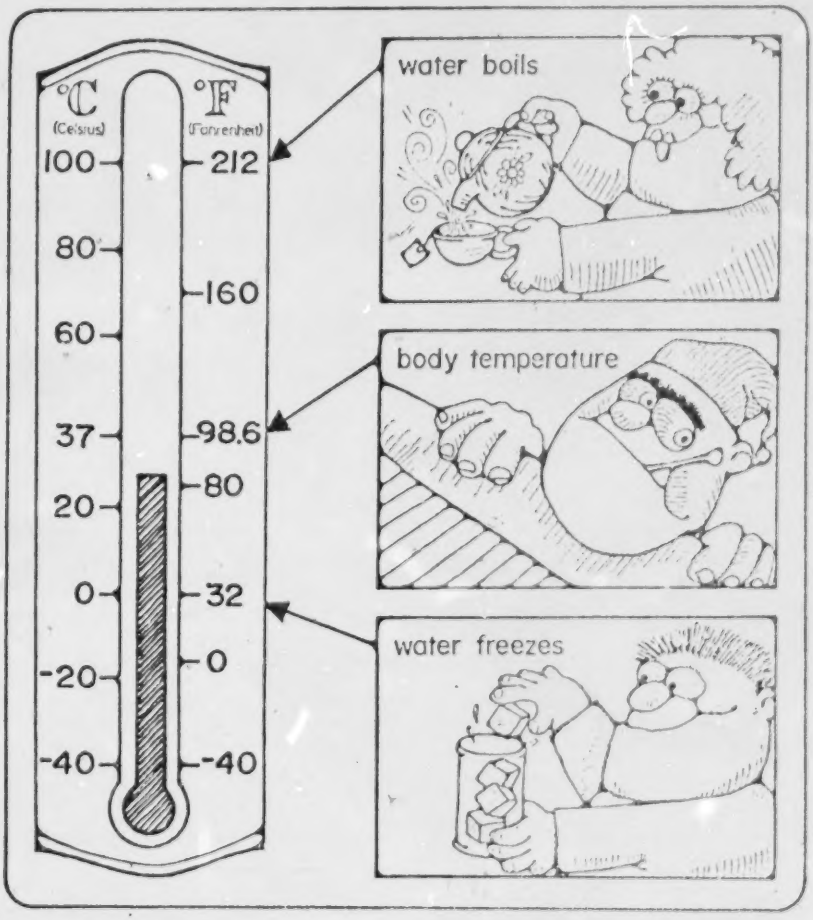
Scientists adopted the metric system immediately, for it made their work much simpler. Nations, on the other hand, have been slow to adopt it. It wasn't until 1840 that the French government made its use mandatory. By 1900, thirty-five nations had officially adopted it, and by the middle of this century, the main holdouts were the English-speaking nations. In 1965, England joined the European Common Market. Since Europe used the metric system, England decided to go metric. The other English-speaking nations soon followed. Ten years later, President Ford signed the Metric Conversion Act of 1975. Finally, after 180 years, the conversion to metric is nearing completion.

LESSON 5: TEMPERATURE

There is one more metric unit which is encountered in daily living, the unit for temperature, degree Celsius (pronounced sell-see-us). Most adults are surprised to learn that "degree Centigrade," which they vaguely remember from their school days, has been changed to "degree Celsius."

The change came about in 1948, at the General Conference on Weights and Measures which convenes periodically to review and ratify measurement standards. A debate arose concerning the name of a unit for metric temperature. Some conferees favored the English "degree Centigrade," and others favored the French "degré centisimal". By coincidence, the centigrade scale had been invented by Anders Celsius. Since his last name started with "C," his name was selected as a compromise.

The Celsius scale is simpler than the Fahrenheit scale. The drawing below illustrates its simplicity. Water boils at 100°C and freezes at 0°C. If you can remember the four temperatures shown on the thermometer, you'll have a good beginning on making sense of the Celsius scale.



LESSON 6: MASS (WEIGHT?)

The purpose of this lesson is to explain the difference between mass and weight. The kilogram is the unit of mass, and the Newton (after Sir Isaac Newton) is the unit of weight.

If you were an astronaut in outer space, the objects in your space craft would have very little weight. If you held a bowling ball in your hand and released it, it wouldn't fall. It would remain suspended in space. If the bowling ball were placed on a scale, it would read zero. It would be weightless. Why? Because the bowling ball is so far from the earth that it has escaped the pull of the earth's gravity.

Weight, then, is a measure of gravitational pull on an object. The weight of an object can vary, depending on where it is in the universe.

The mass of an object never varies. It is the same on earth as anywhere else in the universe. Mass is a measure of how much matter an object contains. The bowling ball is weightless in space, but it still has the same mass. Because of its mass, if you kicked it with your bare foot it would still hurt, whether you were on earth or in a spaceship.

We determine the weight of an object by spring scales which measure the downward pull on an object placed on it. This downward force is measured in Newtons. The mass of an object, on the other hand, is determined by using a balance: the object is placed on one side and balanced with standardized mass pieces. This is what a pharmacist does when he mixes a compound.

However, the mass of an object is directly proportional to its weight on earth. That is, a one-kilogram mass has a weight of about 9.8 Newtons at sea level; a two-kilogram mass has a weight of about 19.6 Newtons; etc. Thus, either mass or weight gives us a good measure of how much matter an object contains. Therefore, in everyday usage spring scales are used for determining mass in kilograms because it is much more convenient than using a balance. The 4M COMPANY uses the words interchangeably - mass (weight). For everyday usage, the distinction is unimportant.

The French scientists made several errors in their original calculations. For example, they miscalculated the distance from the equator to the north pole by about 2000 meters, and instead of being equal to one cubic decimeter, the liter was actually equal to 1.000028 cubic decimeters.

To correct these errors, various scientific organizations of the world met in 1960 to devise a modern metric system which is called the International System of Units (or SI for short, after the French Le Systéme Internationale d'Unités). SI was created to meet the exacting demands for precise scientific measurement. Most of the units and prefixes will not be used by the average citizen. But for the sake of completeness, we include a list of the base units and all the prefixes.

BASE UNITS

Quantity	Name	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Two units not on the list above are commonly used with the metric system. Instead of referring to liquid capacity in terms of cubic decimeters, the liter is used. And instead of using the Kelvin for temperature, degree Celsius is used (the Kelvin scale was derived from the Celsius scale).

PREFIXES

Prefix	Symbol	Pronunciation Symbol	Multiples & Fractions
exa	E	ex´ah	1 000 000 000 000 000 000
peta	P	pet´ah	1 000 000 000 000 000
tera	T	tear´ah	1 000 000 000 000
giga	G	jig´,ah	1 000 000 000
mega	M	meg´ah	1 000 000
kilo	k	kill´oh	1 000
hecto	h	heck´toh	100
deka	da	deck´ah	10
deci	d	dess´ih	0.1
centi	c	cent´ih	0.01
milli	m	mill´ih	0.001
micro	μ	mike´roh	0.000 001
nano	n	nan´oh	0.000 000 001
pico	p	pee´koh	0.000 000 000 001
femto	f	fem´toh	0.000 000 000 000 001
atto	a	att´oh	0.000 000 000 000 000 001

Complete these equations if you can:

1 000 000 lomania = _____

1 000 000 000 ntic = _____

0.000 001 nesia = _____

1 000 000 000 000 tory = _____

0.000 000 000 000 000 001 rney = _____

1 000 000 000 000 000 000 rcist = _____

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LESSON 8: SI STYLE CONVENTIONS

Think of it! There is no universal language, there is no universal monetary system. But at last we stand on the threshold of having a universal measurement system, a system understood by people all over the world. To make communication easier, certain style conventions are recommended. This section cites the major conventions.

1. Use a space to separate large numbers into groups of three. Do not use a comma. In many countries a comma is recognized as a decimal point.

Example:	Correct	Incorrect
	600 300.6	600,300.6

2. Use a zero in front of the decimal point when the numerical value is a partial unit.

Example:	Correct	Incorrect
	0.6 mm	.5 mm

3. Use a decimal to express partial units. Avoid using fractions to express partial units.

Example:	Correct	Incorrect
	0.25 kg	1/4 kg

4. Use uppercase or lowercase letters as they are given in the table. All abbreviations or symbols are to be used in the singular form. Do not use periods after symbols unless they conclude a sentence.

Example:	Correct	Incorrect
	mm (millimeters)	mms or mm's
	cg	c.g.
	ℓ	ℓ.

5. Prefixes must be combined with units. In common usage "kilo" means kilogram. Such usage is not preferred.

6. Avoid mixing units.

Example:	Correct	Incorrect
	12.75 m	12 m 75 cm

7. Avoid using multiple prefixes.

Example:	Correct	Incorrect
	ps (picosecond)	μμs (micromicrosecond)

8. Avoid capitalization of unit names (except Celsius) unless they start a sentence. Listings should be lowercase.

Example: Correct - The base unit for mass is the kilogram.

Incorrect - The base unit for mass is the Kilogram.

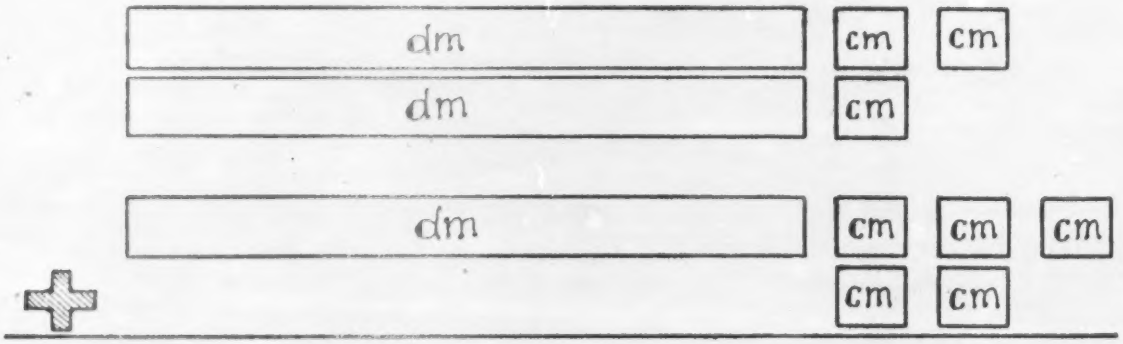
NEXT-TO-LAST-LESSON: DECIMALS

Our number system, our monetary system, and the metric system all share a common characteristic: they are decimal in nature. Because of this, the switch to metric makes the study of decimals even more important than ever. The 4M COMPANY begins the study of decimals in the third grade. The purpose of this lesson is to illustrate how the decimal nature of the metric system is used to teach decimals.

Since a decimeter is one-tenth of a meter, decimeters are used to introduce tenths. Students make a meter strip marked in tenths of meters and use it to measure various lengths.

Similarly, since a centimeter is one-hundredth of a meter, centimeters are used to introduce hundredths. And a millimeter, being one-thousandth of a meter, is used to introduce thousandths.

Addition and subtraction of decimals are explained in terms of metric units. Thus, the problem $\begin{array}{r} 0.23\ \text{m} \\ +0.15\ \text{m} \\ \hline \end{array}$ is represented as follows:



If placed end-to-end, these units would come to the 0.38 m mark on a meter marked in hundredths. Since 10 centimeters can be exchanged for 1 decimeter, borrowing and carrying are easily explained in terms of metric units. The students soon see that adding and subtracting decimals is very similar to adding and subtracting whole numbers.

LAST LESSON: METRIC FOR EVERYDAY LIVING

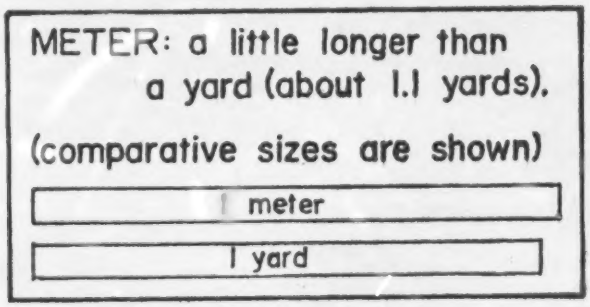
In this section we list those metric units which are most commonly used in everyday living.

Length: 1) A meter is a little longer than a yard.

2) A kilometer (1000 meters) is about 6/10th of a mile.

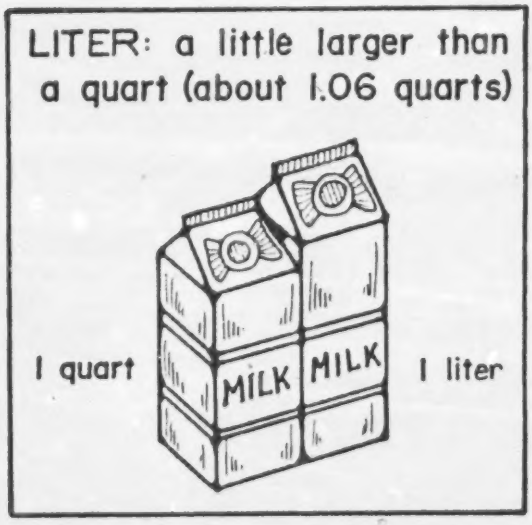
3) A centimeter (0.01 meter) is about the width of a paper clip.

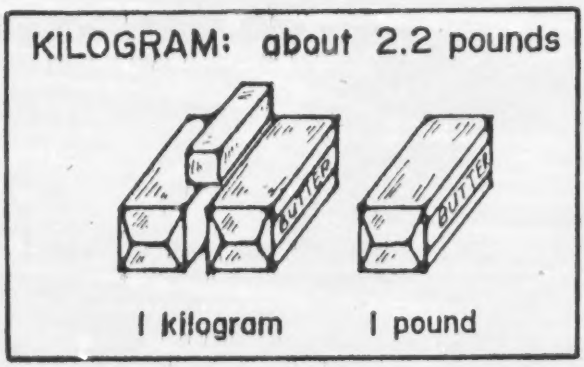
4) A millimeter (0.001 meter) is about the thickness of a dime.



Capacity: 1) A liter is a little larger than a quart (about 1.06 quarts).

2) A milliliter is 1/5th of a teaspoon.





Mass: 1) A gram is the mass of two small thumb tacks.

2) A kilogram is about 2.2 pounds.

3) A metric ton is 2200 pounds.

4) A milligram is the weight of a bee's wing.

ANSWERS TO PROBLEMS

LESSON 3:

hectogram	deciliter
dekaliter	centiliter
kilometer	decigram
milligram	dekagram
hectoliter	dekacards
centigram	deciArnaz
millimeter	centimentalist
centimeter	kilomanjaros
milliliter	millitary
hectoliter	decimate
kiloliter	kilowhats?
kilogram	milliscent
dekameter	centipede
decimeter	

LESSON 7:

megalomania
jigantic
micronesia
teratory
attorney
exarcist